CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-135

September 30, 1982

1. Name of faults

Chianti, Healdsburg, Alexander, Maacama, and related faults.

2. Locations of faults

Mark West Springs, Healdsburg, Mount St. Helena, Jimtown, and Geyserville 7.5-minute quadrangles, Sonoma County (figure 1).

3. Reason for evaluation

Part of 10-year fault evaluation program (Hart, 1980).

4. List of references

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5. Review of available data

Special Studies Zones Maps of the Mark West Springs, Mount St. Helena, Healdsburg, Jimtown, and Geyserville 7.5-minute quadrangles were originally issued in 1976 (figures 2a-2d). Potentially-active faults (displacement during Quaternary time) were zoned for special studies based on the mapping of Huffman and Armstrong (1980; maps in press at the time SSZ Maps were issued). Currently, it is the policy of the California Division of Mines and Geology to zone only those faults that are "sufficiently active" (Holocene) and "well-defined" (Hart, 1980). Thus, the above-mentioned SSZ Maps will be re-evaluated in this Fault Evaluation Report (FER) using the current criteria.

The southern part of the FER study area represents a region of recent tectonic complexity. Herd (1978) and Cockerham and Herd (1982) postulate a large right-step of recently-active, right-lateral, strike-slip displacement from the Rodgers Creek-Healdsburg fault zone north to the Maacama fault zone. Herd (in press; p.c., 1981) states that geomorphic evidence of north to northeast-trending extensional faults south of the FER study area supports the existence of a right-stepping connection between the Rodgers Creek-Healdsburg fault zone and the Maacama fault zone.

Maacama Fault Zone

Gealey (1951) was the first to name the Maacama fault zone. He recognized evidence of recent activity along the Maacama fault between Sausal and Gird Creeks and along Miller Creek, such as ponded alluvium and the right-lateral deflection of Miller Creek (localities 1 and 2, figure 2c). Blake, et al. (1971) mapped the Maacama fault zone in the Jimtown and Geyserville quadrangles, although they did not indicate that the Maacama fault zone was recently active. Fox, et al. (1973) mapped traces of the Maacama fault zone in the Mount St. Helena and Mark West Springs quadrangles, although they also did not indicate recent activity along the fault zone.

Huffman and Armstrong (1980) indicate that the Maacama fault zone, which is largely based on the mapping of Blake, et al. (1971), is Quaternary-active (figures 2a, 2c, 2d). Huffman and Armstrong indicate that the classification of strands of the Maacama fault zone as Quaternary-active are based primarily on air photo interpretation by Huffman.

Herd, et al. (1977) mapped Quaternary-active faults of the Maacama fault zone in the FER study area (figures 2a, 2b, 2c). Their annotated maps depict a discontinuous zone of faulting with geomorphic evidence of possible Holocene activity (figures 2a, 2b, 2c). Herd and Helley (1977) depict the Maacama fault the same as Herd, et al. (1977) and indicate that the fault is Pleistocene-active, but does not have evidence of Holocene activity (Holocene deposits not offset by the fault).

McLaughlin (1978) completed a detailed geologic map of the area incorporating a part of the Geysers geothermal area. McLaughlin's map includes a part of the Jimtown quadrangle (figure 2c). Although McLaughlin does not classify faults with respect to recency, he does map the fault as offsetting alluvium where it crosses Miller Creek and just north of locality 3 (figure 2c).

The U.S. Army Corps of Engineers released a study of the Maacama fault zone in 1978. Although the region studied is north of this FER study area, the Corps of Engineers documented some geomorphic evidence indicating Holocene faulting along the Maacama fault zone, based primarily on air photo interpretation, literature research, and limited field checking.

Pampeyan (1979) classified strands of the Maacama fault as Holocene-active in the Geyserville and Jimtown quadrangles (figure 1).

Segments of the Maacama fault zone in the southern half of the Jimtown and Mark West Springs quadrangles are classified generally as late-Pleistocene active rather than Holocene-active by Pampeyan (1979).

Herd (in press) slightly revised the fault traces depicted by Herd, et al. (1977) and Herd and Helley (1977) (figures 2a, 2c, 2d). Herd states that fault segments within this part of the Maacama fault zone are late-Quaternary active, although unpublished maps provided to this writer do not have annotations documenting recency of faulting.

The Maacama fault zone in this FER study area is located primarily in rugged, hilly regions where development is extremely limited. Thus, only a few site-specific investigations for delineating recently active faults have been conducted. Herzog and Associates (1979) excavated trenches near faults mapped by Herd, et al. (1977) (figure 2c). Although a set-back was recommended, no conclusive evidence of recent faulting was observed in the trenches. The presence of colluvial/alluvial deposits in two trenches, rather than the Sonoma Group (Blake, et al., 1971, map tuff of the Glen Ellen Formation at this location), was sited as evidence for faulting. Because the colluvial/alluvial deposits could not be shown to be older than 11,000 years, set-backs were recommended. No evidence of shears or offsets were mentioned, and the consultant did not consider alternative geologic processes for the occurrence of the colluvium/alluvium.

Healdsburg Fault Zone

The Healdsburg fault zone depicted on the 1976 SSZ Maps of the Mark West Springs, Healdsburg, Jimtown, and Geyserville quadrangles is based on mapping by Huffman and Armstrong (1980; in press at time of SSZ Map issue) (figures 2a-2d). The fault traces of Huffman and Armstrong are based largely on mapping by Blake, et al. (1971) and Brown (1970), supplemented by air photo interpretation and minor field examination by Huffman and Armstrong.

Gealey (1951) first recognized evidence of recent activity along the Healdsburg fault zone. Evidence of Quaternary activity along the Healdsburg fault cited by Gealey includes ponded alluvium and beheaded valleys in sections 5 and 6, T8N, R8W (figure 2b), and geomorphic features along the fault such as linear drainages, oversteepened slopes, aligned knobs, closed depressions, and sheared, linear masses of serpentine.

Herd, et al. (1977) and Herd and Helley (1977) do not consider most of the Healdsburg fault to be Quaternary-active. They state that recently active faults located north of Santa Rosa and just south of this FER study area are a part of the Rodgers Creek fault zone, while Huffman and Armstrong contend that these faults are part of the southern Healdsburg fault zone. Herd, et al. and Herd and Helley map a discontinuous and partly concealed fault in the southern Mark West Springs and Healdsburg quadrangles (figures 2a and 2b). Farther to the northwest, they did not observe geomorphic evidence of Quaternary offset, except for a short, northwest-trending fault segment just south of Lytton (locality 4, figure 2c). This short fault segment is characterized by a linear ridge in Pleistocene sediments and a linear contact between Holocene and Pleistocene deposits.

Huffman and Armstrong further delineate evidence for Quaternary offset along the Healdsburg fault zone in an in-house memo dated February 1, 1978. They met with Herd to field check, in part, locations along the Healdsburg fault in sections 17, 8, 7, and 6, T8N, R8W (figure 2b). A series of right-laterally deflected drainages with associated saddles is considered by Huffman and Armstrong to be evidence of recent faulting (locality 5, figure 2b). Herd contends that differential erosion along bedding formed these features. Huffman and Armstrong counter that beds of the Plio-Pleistocene Glen Ellen Formation dip very shallow or are horizontal west of the fault zone and state that beds with steeper dips are due to deformation along the Healdsburg fault. Huffman and Armstrong demonstrated Quaternary offset, but Holocene activity was not demonstrated. A roadcut on the south side of Chalk Hill Road exposed beds of the Glen Ellen Formation dipping about 45° to the southwest, partly confirming the interpretation of Huffman and Armstrong (probable deformation of Quaternary beds), and also the interpretation of Herd (beds with moderate-to-steep dips along which differential erosion forms linear and deflected drainages).

Armstrong and Huffman (1979) map a part of the Healdsburg fault zone in the Healdsburg 7.5-minute quadrangle, showing geomorphic evidence of recent faulting. The location of fault traces differs slightly from the faults depicted on the 1976 SSZ Map of the Healdsburg quadrangle (figure 2b). They attribute the 1969 Santa Rosa earthquakes to the Healdsburg fault, based on the spatial association of the epicenters with the southern segment of the fault. They state that the southern Healdsburg fault zone is characterized by geomorphic evidence of Holocene activity, such as closed depressions, scarps, deflected drainages, troughs, and benches. Farther northwest along the fault zone, geomorphic features become more subtle and less numerous, suggesting either a decrease in fault activity or an increased rate of erosion.

Pampeyan (1979) classifies the Healdsburg fault as Holocene-active, based largely on Huffman and Armstrong (1980).

Brown (letter to E. Hart, September 16, 1982) concludes that evidence for continuous, active faulting along the Rodgers Creek-Healdsburg fault zone north of Mark West Creek is much less convincing than farther to the south along the Rodgers Creek fault zone.

A few site-specific fault hazard investigations have been performed along traces of the Healdsburg fault zone (figures 2a, 2b, 2c). Most of these reports are inconclusive. Investigations by Moore and Taber (1975) and Cooper-Clark (1979) in the southwestern corner of the Mark West Springs quadrangle (figure 2a) did not expose evidence of faulting in Holocene alluvium. A site investigation by Harding-Lawson (1979) in the southwestern corner of the Jimtown quadrangle revealed possible evidence of recent faulting (figure 2c). Shallow-dipping faults (dipping into hill) were observed, and two faults (indicated on figure 2c) seemed to offset soil. However, the wrong sense of displacement was observed in some of the trenches, soil was not displaced systematically, and it is possible that downhill creep has disturbed soil-bedrock relationships. Geomorphic evidence of recent faulting was not observed at or near the site. Huffman and Armstrong (1980) map a landslide at this location, and air photo interpretation by this writer verifies this. The landslide is probably an older slide that has partly stabilized, although smaller, more recent slope failures were mapped by the consultant. However, the consultant did not mention the large landslide, and trenches, which averaged about five feet deep (maximum depth about 7' to 10'), did not reveal evidence of sliding, except perhaps for the shallow dipping shears.

Chianti Fault

The Chianti fault was first named by Gealey (1951). He postulated recent activity along the Chianti fault based on ponded alluvium east of Chianti (figure 2d).

Blake, et al. (1971) map a segment of the Chianti fault in the FER study area, but do not indicate that the fault is recently active. Huffman and Armstrong (1980) map the Chianti fault as Quaternary-active, based on the right-lateral deflection of Gill Creek and the ponding of alluvium at locality 6, (figure 2d). Herd, et al. (1977) and Herd and Helley (1977) consider segments of the Chianti fault to be Quaternary-active north of the FER study area, but they did not observe evidence of Quaternary activity within the FER study area. Pampeyan (1979) classifies the Chianti fault as late-Quaternary active, but not Holocene-active within the FER study area (figure 1).

Smith (1981) observed evidence of possible Holocene activity about two mile north of the FER area, but from that point south, he stated that the fault was not well-defined.

Alexander Fault

The Alexander fault, first named by Gealey (1951), is considered by Huffman and Armstrong (1980) to be a northern extension of the Healdsburg fault zone. Blake, et al. (1971) map the Alexander fault, but they do not indicate that the fault is recently active.

Huffman and Armstrong (1980) indicate that the Alexander fault is Quaternary-active. Evidence for Quaternary offset includes: 1) a roadcut exposure along Dutcher Creek Road which reveals Quaternary terrace deposits offset against serpentinite (overlying soil was not offset), and 2) geomorphic features characteristic of recent faulting such as deflected drainages and ponded alluvium. Much of the evidence of recent faulting along the Alexander fault is located just north of the FER study area and was evaluated by Smith (1981). Smith did not observe evidence of a Holocene-active fault, although he did conclude that a pre-Holocene fault exists.

Herd, et al. (1977), Herd and Helley (1977), and Herd (in press) do not consider the Alexander fault to be late-Quaternary active. Pampeyan

(1979) classifies the Alexander fault to be late-Pleistocene rather than Holocene-active.

Inferred Fault A

An unnamed fault trending parallel to Dry Creek was first mapped by Blake, et al. (1971). They consider the fault to be recently active, and indicate that the fault offsets Quaternary terrace deposits and infer that alluvium is offset. Huffman and Armstrong (1980) also map this fault, but depict the fault as queried and inferred (figure 2d).

Pampeyan (1979), Herd, et al. (1977), and Herd and Helley (1977) do not map Inferred fault A.

Inferred Fault B

Inferred fault B, mapped by Blake, et al. (1971), is considered to be recently active (figure 2b). They indicate that Plio-Pleistocene Glen Ellen Formation and recent alluvium are offset. Huffman and Armstrong (1980) depicted this fault as queried and inferred (figure 2b). Pampeyan (1979) classifies Inferred fault B as Holocene-active based on the offset alluvium at locality 4 (figures 1, 2b). However, Pampeyan maps the fault as queried. Armstrong and Huffman (1979) indicate that Inferred fault B offsets Plio-Pleistocene Glen Ellen Formation northwest of section 1, T8N, R9W (figure 2b). Armstrong and Huffman (1979) did not map recent alluvium southeast of section 1 as offset along Inferred fault B.

Seismicity

Microseismicity within and just south of the FER study area is depicted on figure 3 (Marks and Bufe, 1978). The Rodgers Creek fault zone is fairly well-defined by the seismicity. Earthquakes of M5.6 and M5.7 occurred near Santa Rosa in 1969 and are clearly associated with the Rodgers Creek-Healdsburg fault zone. North of the area near Chalk Hill Road (figure 2b), the seismicity begins to trend more northerly toward the Maacama fault zone. To the northwest, the seismicity aligns along the Maacama fault zone. Fault plane solutions along the Maacama fault zone in the FER study area are consistent with right-lateral strike-slip faulting (Bufe, et al., 1981) (figure 4).

6. Air photo interpretation

Results of brief air photo interpretation by this writer are summarized on figures 2a-2d. Due to the limited amount of time available in the preparation of this FER, the primary emphasis was to verify the mapping of Huffman and Armstrong (1980), Herd, et al. (1977), and Herd (in press), rather than compiling an independent interpretation of recently active faults.

Much of the area along the Maacama fault zone is underlain by Franciscan bedrock and is located in relatively steep, rugged terrain. Landslides are abundant along the fault zone and obscure or conceal large stretches of the fault zone. The Healdsburg fault zone similarly is located primarily within rugged terrain, but occurs predominately in rocks of Plio-Pleistocene Glen Ellen Formation and, locally, volcanic rocks of the Pliocene Sonoma Volcanics and Jurassic-Cretaceous Great Valley Sequence. Landslides are abundant along the Healdsburg fault zone primarily in the northern half of the Healdsburg 7.5-minute quadrangle.

Maacama Fault Zone

Significant stretches along the Maacama fault zone are obscured or concealed by landslides. Geomorphic features indicating possible Holocene activity along the Maacama fault zone in the northern part of the study area include scarps, ponded alluvium, closed depressions, and right-laterally deflected drainages (figures 2d, 2c). These geomorphic features delineate multiple strands of the Maacama fault zone, indicating a distributive pattern of faulting possibly modified by downslope movement.

The Maacama fault zone is difficult to follow and is concealed by landslides between locality 7 (figure 2c) southeast to where the fault crosses Miller Creek. Ponded alluvium, a linear scarp, oversteepened slopes on trend with the fault, and the right-lateral deflection of Miller Creek indicate possible Holocene-active faults. The Maacama fault is concealed by complex landslide features from locality 8 southeast to Gird Creek (figure 2c). Faults mapped by Herd (in press) west of the main trace of the Maacama fault generally are not well-defined.

A broad sidehill trough from Gird Creek southeast to locality 3 delineates the main trace of the Maacama fault zone (figure 2c). Ponded alluvium, a possible beheaded drainage, and scarps suggest Holocene activity. Southeast of locality 3 to Sausal Creek the Maacama fault is not well-defined, although its location can be inferred based on the location of two benches. Herd (in press) maps several scarps in alluvium west of the main trace of the Maacama fault (figure 2c). However, these fault traces are dissected and may be older faults that have been mantled with recent alluvium.

From Sausal Creek southeast to Maacama Creek, the fault zone is characterized by systematically right-laterally deflected drainages and ponded alluvium (figure 2c). Maacama Creek is deflected right-laterally, and well-defined traces of the fault zone can be followed to locality 9 (figure 2a).

South of locality 9, the Maacama fault zone is located along essentially linear, major drainages (figure 2a). The fault zone is moderately well defined in general, but not in detail, due to relatively rapid rates of erosion and massive landslides. The fault is characterized by linear ridges and drainages, right-laterally deflected drainages, and a linear trough in a saddle (figure 2a). Southeast of section 35, T9N, R8W, the Maacama fault is not well-defined, and no compelling geomorphic evidence of offset during Holocene time was observed (figure 2a).

Healdsburg Fault Zone

The Healdsburg fault zone is only locally well-defined in the southern part of the FER study area. Southeast of section 17, T8N, R8W, the fault zone is characterized by geomorphic features indicating possible Holocene offset such as right-laterally deflected drainages, closed depressions, and linear scarps and troughs (figures 2a, 2b). A fairly linear hillfront in sections 20 and 17, T8N, R8W is associated with drainages that seem to indicate a vertical component of displacement (figure 2b).

The Healdsburg fault is delineated by a dissected linear ridge with associated right-laterally deflected ridges in sections 7 and 8, T8N, R8W (figures 2b). Near the center of section 6, the fault is well-defined and is characterized by a linear trough, a sidehill bench, a scarp in alluvium (?), and ponded alluvium (figure 2b). From section 36, T9N, R9W northwest to near Highway 101, the Healdsburg fault is not well-defined.

A short segment of the Healdsburg fault just south of old Highway 101 is characterized by a linear ridge and an east-facing scarp (locality 4, figure 2c). The linear ridge is underlain by rocks of the Cretaceous Great Valley Sequence. The ridge is due to faulting, but the linear contact with Holocene alluvium is probably the result of deposition rather than faulting. Drainages north and south of the linear ridge are not offset (figure 2c). No geomorphic evidence indicating Holocene-active faults was observed along the Healdsburg fault zone northwest of Highway 101 (figures 2c, 2d).

Chianti Fault

The Chianti fault is generally not well-defined in the FER study area. Gealey (1951) indicated that ponded alluvium and a right-laterally deflected drainage at locality 6 (figure 2d) were evidence of recent faulting. However, there is no geomorphic evidence of Holocene faulting in the alluviated basin, and the Chianti fault is poorly defined southeast of the basin (figure 2d).

Alexander Fault

The Alexander fault is primarily delineated by geomorphic features, such as aligned benches, saddles, linear drainages, and occasional right-laterally deflected drainages (figure 2d). However, clear evidence of Holocene offset was not observed in the Healdsburg quadrangle.

Inferred Fault A

Geomorphic evidence supporting the existence of a Holocene-active fault along Inferred fault A was not observed. Local right-laterally deflected drainages are not associated with additional geomorphic evidence indicating Holocene activity. Evidence of Quaternary displacement is suggested by discontinuous tonal lineaments, saddles, and vague, eroded scarps, but generally these features are not well-defined. There is no geomorphic evidence indicating offset of recent alluvium.

Inferred Fault B

Geomorphic evidence of Quaternary offset locally occurs within the Plio-Pleistocene Glen Ellen Formation, but geomorphic evidence indicating

Holocene displacement was not observed (figure 2b). Generally, Inferred fault B is not well-defined, and geomorphic evidence of recent faulting in alluvium from section 7, T8N, R8W southeast to section 17, T8N, R8W was not observed (figure 2b).

7. Field investigations

A brief, one-day field reconnaissance of the study area was made, primarily to check areas along the Maacama fault for evidence of fault creep. No evidence of fault creep was observed. However, only three paved roads cross the fault zone in the FER study area, so negative evidence of fault creep was not conclusively established.

8. Conclusions

Evidence of recently active right-lateral displacement along the Healdsburg fault zone seems to be stepping right (east) to the Maacama fault zone. This is indicated by the following lines of evidence: 1) the decrease in geomorphic evidence of recent faulting along the Healdsburg fault zone northwest of section 36, T9N, R9W (figure 2b); 2) the corresponding increase of geomorphic evidence of recent faulting along the Maacama fault zone northwest of section 35, T9N, R8W (figure 2a); and, 3) a shift in microseismicity from the Rodgers Creek-Healdsburg fault zone to the Maacama fault zone which very roughly corresponds to the surface expression of the fault zones (figures 2a-2d; 3).

The Maacama fault zone is a discontinuous zone of moderately well-defined faults that locally are concealed by massive landslides. Geomorphic features indicating Holocene displacement are present to some degree along the fault zone from the northern part of the study area southeast to about section 35, T9N, R8W.

The Healdsburg fault zone is locally well-defined and is charaterized by geomorphic features indicating possible Holocene activity from section 36, T9N, R9W southeast to the southern boundary of the FER study area. The Healdsburg fault northwest of section 36 is generally poorly defined and lacks geomorphic evidence indicating Holocene displacement.

The Chianti fault is generally poorly defined in the FER study area. A right-laterally deflected drainage and ponded alluvium suggest recent activity, but geomorphic evidence of Holocene offset was not observed. Smith (1981) stated that the southern part of the Chianti fault was not well-defined and recommended deleting the SSZ.

The Alexander fault is locally well-defined and geomorphic evidence suggesting late-Quaternary displacement is locally present, although generally to the north of the FER study area. Smith (1981) did not observe ephemeral geomorphic evidence indicating Holocene activity along the Alexander fault just north of the FER study area and recommended removing the SSZ.

Inferred faults A and B are generally poorly defined and lack evidence of activity during Holocene time.

9. Recommendations

Recommendations for zoning faults for special studies are based on the criteria of sufficiently active and well-defined (Hart, 1980).

Zone for special studies well-defined traces of the Maacama fault zone, depicted on figures 5a-5b, based on mapping by Herd, et al. (1977), McLaughlin (1978) Huffman and Armstrong (1980), and Herd (in press). Do not zone traces of the Maacama fault zone southeast of section 35, T9N, R8W (figure 2a).

Zone for special studies well-defined traces of the Healdsburg fault zone depicted in figures 5a and 5b, based on mapping by Huffman and Armstrong (1980) and Herd, et al. (1977). Do not zone traces of the Healdsburg fault zone northwest of section 36, T9N, R9W.

10. Report prepared by William A. Bryant, September 30, 1982.

William A. Bryant

Recommendations appear reasonable. EWH 10/30/82

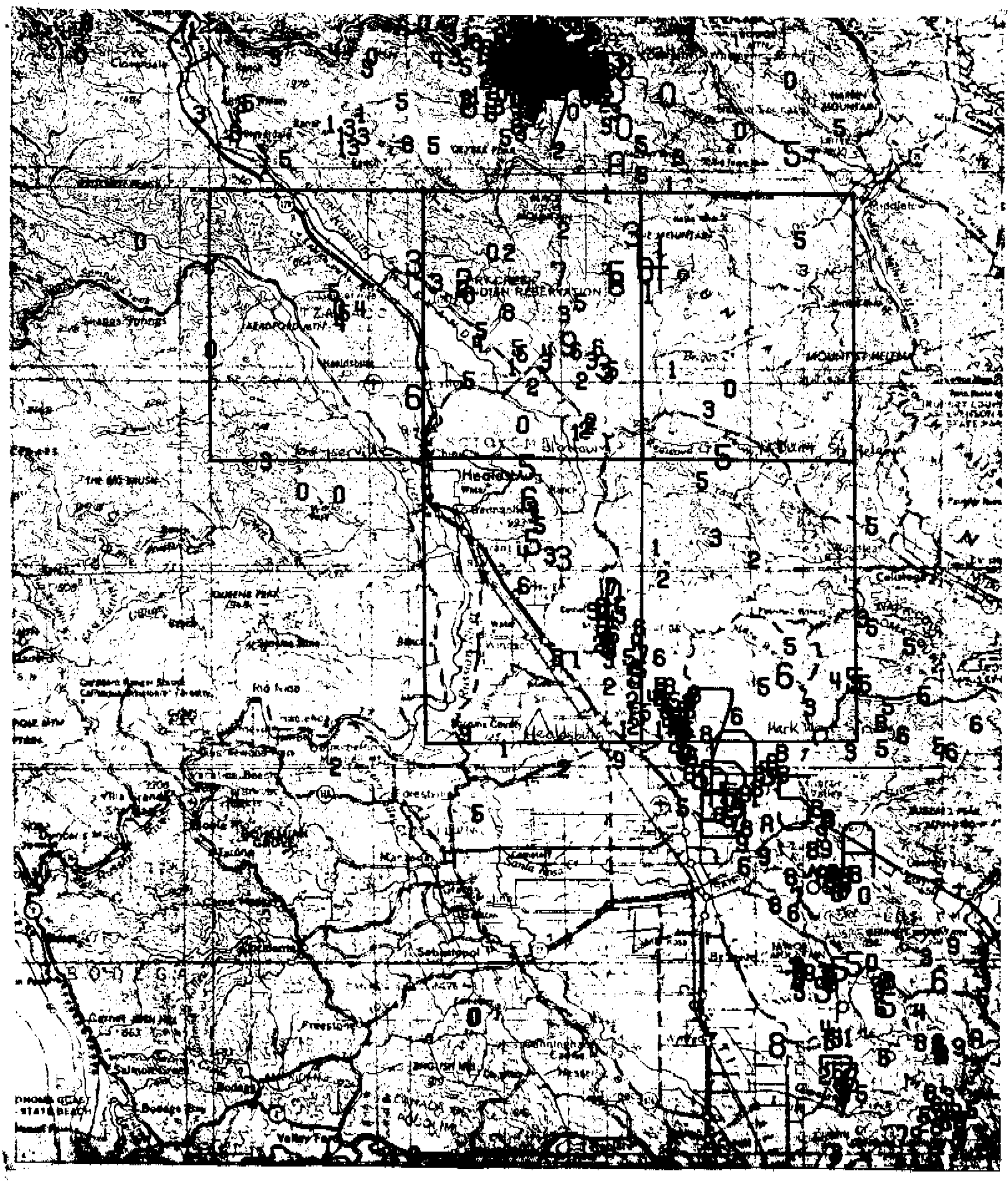

Figure 3 (to FER-135). Map of the seismicity of the FER area and surrounding region for the period January 1969 to June 1977. From Marks and Bufe (1978) (scale 1:250,000).

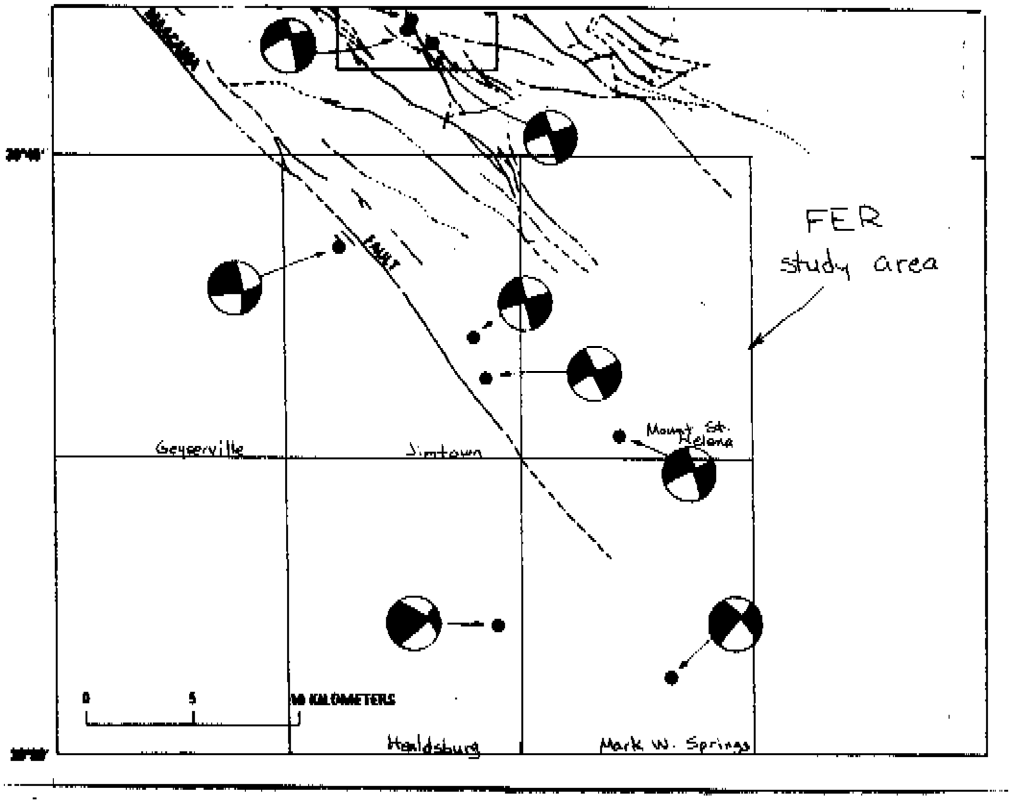

Figure 4 (to FER-135). Fault plane solutions (lower hemisphere) for earthquakes along the Maacama fault zone. Compressional quadrants are shaded. From Bufe, et al (1981).